Geostationary Operational Environmental Satellite (GOES)

GOES-R Series

Unique Instrument Interface Document (UIID)

Hyperspectral Environmental Suite (HES)

Draft

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To verify the correct version of this document, please contact the GOES R Series Requirements Management Office on 301-286-7898

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1 Scope

The purpose of this Unique Instrument Interface Document (UIID) is two-fold. The first is to allocate the resources of the GOES-R series spacecraft to the Hyperspectral Environmental Suite (HES). The second is to document Government-approved constraints on instrument operation and deviations or waivers to the GOES-R Instrument Requirements Document (GIRD).

The spacecraft integrating contractor and the HES contractor **shall** meet each of their respective interface requirements as defined in this document.

The government will be the system integrator until a system performance contractor or spacecraft contractor with that responsibility is selected. Until that time, the government will be responsible for accommodation trades, resource allocation (weight, power, space, bandwidth, etc.), and resolving interface issues. This UIID will govern the development of an Interface Control Document (ICD) which will be a joint activity of the HES and spacecraft contractors.

The HES ICD establishes the details of the electrical, communications, mechanical, thermal, integration and test, and command and data handling (C&DH) interfaces between the HES instrument and the GOES-R spacecraft. After the ICD is signed and approved by all parties, the spacecraft contractor **shall** maintain the ICD.

1.1 Document Overview

Together, the GIRD and the HES UIID establish the HES-spacecraft interface requirements. The GIRD applies to all GOES-R instruments while the HES UIID is specific to the HES. Section 1 explains the use of this document. Section 2 lists reference documents. Section 3 allocates spacecraft resources, such as mass, power, and data rate, to the HES instrument. Section 4 contains verification guidelines. Section 5 contains government-accepted constraints requested by the contractor. Section 6 contains government-accepted deviations from the GIRD.

1.2 Missing Requirements

This document contains all performance requirements for the sensor except those labeled “TBD”, “TBS”, and “TBR”. The term “TBD” (To Be Determined) means that the contractor should determine the missing requirement in coordination with the government. The term “TBS” (To Be Specified) indicates that the government will supply the missing information in the course of the contract. The term “TBR” (To Be Reviewed) implies that the requirement is subject to review for appropriateness by the contractor or the government. The government may change “TBR” requirements in the course of the contract.

1.3 Definitions

The statements in this document are not of equal importance.

“Shall” designates a requirement. Any deviations from requirements requires approval of the NASA contracting officer.

“Will” designates a statement of fact about the system, its operational environment or the intent of the government. It is not a contractor requirement.

2 Applicable Documents

The following documents are for reference and do not form part of this specification.

Document Number	Title
GSFC 417-R-HESPORD-0020 June 2003	GOES Hyperspectral Environmental Suite (HES) Performance and Operational Requirements Document (PORD)
GSFC 417-R-GIRD-0009 June 2003	GOES-R Instrument Requirements Document (GIRD)

3 Allocations

The GOES-R spacecraft provides communications, power and a platform for the HES instrument. The following paragraphs allocate these resources to HES. Unless otherwise noted, allocations are for the entire instrument suite.

3.1 Command and Data Handling

3.1.1 Instrument-to-Spacecraft Data Volume

The instrument **shall** send the spacecraft no more than 20 billion (10^9) bits in a five-minute period.

3.1.2 Telemetry Data Rate

The instrument **shall** send engineering and telemetry source packets to the spacecraft at a rate of 1 packet per second (TBR).

3.2 Power

3.2.1 Average Power

The instrument **shall** draw no more than 550 watts averaged over TBS hours.

3.2.2 Peak Power

The instrument **shall** draw no more than 605 watts averaged over TBS seconds.

3.2.3 Survival Power

The instrument **shall** require no more than 290 (TBR) watts to maintain survival temperatures.

3.2.4 Cabling

The length of harness cables between HES units **shall** not exceed the length limits in Table 3.2.4.

Table 3.2.4: Instrument External Harness Cable Length Limits (TBR)

Item	Module Cable Connections	Length (m)
1	Electronics-to-sensor	4 (TBR)
2	Electronics units-to-sensor	4 (TBR)
3	Electronics units-to-electronics units	2.5 (TBR)

3.3 Mechanical

The requirements in this section apply to the structural and mechanical components of the instrument flight units (sensor unit, electronics unit and, if applicable, auxiliary electronics unit).

3.3.1 Mass Properties

The instrument, including all units and cabling between units, **shall** have mass less than 280 kilograms.

3.3.2 Volume

The instrument, including sensor and electronics units, mounts, thermal blankets and connectors for both stowed and operational configurations **shall** not exceed the limits listed in Table 3.3.2.

Table 3.3.2 Instrument Envelope (TBR)

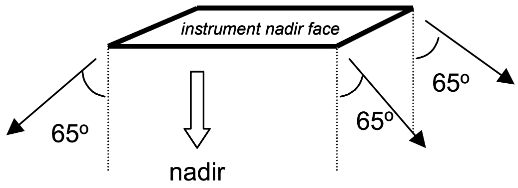
Component	Width (cm)	Height (cm)	Depth (cm)
Sensor Units*	250	130	150
Electronics unit #1	40	40	65
Electronics unit #2	40	40	65

*For the sensor unit, width is east-west. Height is north-south. Depth is nadir-zenith.

3.3.3 Optical Port Field-of-View

The spacecraft **shall** provide the entire instrument nadir face a clear field-of-view within 65^{o} of nadir as shown in Figure 3.3.3.

Figure 3.3.3 Optical Port Field-of-View



3.3.4 Radiator Field-of-View

The spacecraft **shall** provide the instrument north or south face a clear field-of-view to space within 90° of north or south for radiant cooling.

3.3.5 Mounting

The spacecraft **shall** provide the instrument sensor unit a nadir-facing mounting surface.
The spacecraft mounting surface **shall** have as a minimum the same dimensions of the sensor unit envelope anti-nadir plane.
The sensor unit mechanical interface **shall** lie within the anti-nadir plane of the sensor unit envelope.

3.4 Instrument-to-Spacecraft Disturbances

These requirements apply while the instrument is in orbit and operating.

3.4.1 Pointing Error

For each orthogonal axis on the spacecraft side of the sensor unit interface, the operation of the sensor unit **shall** contribute less than 100 microradians to total spacecraft attitude pointing error.

3.4.2 Angular Rate Error

For each orthogonal axis on the spacecraft side of the sensor unit interface, the operation of the sensor unit **shall** contribute less than 40 microradians per second in magnitude to the total spacecraft pointing error rate below 15 Hz.

3.4.3 Acceleration Error

For each orthogonal axis on the spacecraft side of each sensor unit interface, the operation of the sensor unit **shall** contribute less than the magnitude limits specified in Table 3.4.2 to total linear acceleration between frequencies f_1 and f_2.

Table 3.4.2: Instrument-to-Spacecraft Linear Acceleration Limits

f_1 (Hz)	f_2 (Hz)	Peak Limit (mg)
0.0	512.0	6.0
0.9	10.1	0.6
6.3	32.0	0.1
20.2	101.6	0.6
64.0	322.5	2.8
203.2	512.0	5.6

3.4.4 Predicted Force

The instrument **shall** provide the spacecraft with predicted interface forces resulting from HES operation.

3.4.5 Predicted Torque

The instrument **shall** provide the spacecraft with predicted interface torques resulting from HES operation.

3.5 Predicted Instrument Force and Torque (PIFT)

3.5.1 PIFT Contents

The instrument **shall** predict forces and torques resulting from normal instrument operations.
The instrument **shall** compute the predicted forces and torques in the instrument coordinate system.

3.5.2 PFT Timing

The instrument **shall** use a uniformly spaced series of future times for predicting forces and torques.
The instrument **shall** ensure each future time value sent to the spacecraft leads the present spacecraft time by at least 250 ms (TBR).
The instrument **shall** increment the future time values by 50 ms (TBR) or less.

3.5.3 PIFT Resolution

The instrument **shall** provide the force data with a least significant bit of 0.001 N (TBR).
The instrument **shall** provide the torque data with a least significant bit of 0.001 N-m (TBR).

3.5.4 PIFT Accuracy

The instrument **shall** predict the forces with an accuracy of ±0.03 N (TBR).

The instrument **shall** predict the torques with an accuracy of ±0.03 N-m (TBR).

3.5.5 PIFT Format

The instrument **shall** send the predicted forces, torques and future times to the spacecraft in accordance with GIRD-421 (Section 3.2.5 Command and Data Handling).
The instrument **shall** provide the future time data using the P-field format in GIRD-453 (Section 3.2.5.7.4 Figure Time Code Format).

4 Verification

The following paragraphs outline the verification process the contractor should follow to demonstrate compliance with the preceding requirements.

4.1 Command and Data Handling

4.1.1 Instrument-to-Spacecraft Data Volume

TBS

4.1.2 Telemetry Data Rate

TBS

4.2 Power

4.2.1 Average Power

Test - Operate instrument in all modes and average power over TBS hours.

4.2.2 Peak Power

Test - Operate instrument in all modes and monitor average power at TBS-second intervals.

4.2.3 Survival Power

Test - Cycle instrument through expected worst-case temperature cycles providing only survival power. Check for proper operation afterward.

4.3 Mechanical

4.3.1 Mass Properities

Inspection - Weigh instrument units and cabling, add and compare to limit.

4.3.2 Volume

Inspection - Measure dimensions of instrument units and compare to limit.

4.3.3 Optical Port Field-of-View

Analysis - Compute clearance angle from corners of allocated nadir face.

4.3.4 Radiator Field-of-View

Analysis - Compute clearance angle from corners of allocated north-south face.

4.3.5 Mounting

Inspection - Measure dimensions of instrument mounting surface.

4.4 Instrument-to-Spacecraft Disturbances

It is expected that the instrument contractor will compute time history responses resulting from sensor unit operations. These responses include:

- spacecraft pointing error displacements and rates
- linear acceleration for spacecraft side of sensor mounts

The responses will be compared against the sensor unit contributed limits defined in section 3.4 Instrument-to-Spacecraft Disturbances.

Responses should be computed using math models of the spacecraft supplied by the spacecraft contractor. These math models will include spacecraft vibrational dynamics and attitude control. Prior to obtaining spacecraft math models, responses should be computed using the Laplace domain spacecraft attitude transfer function

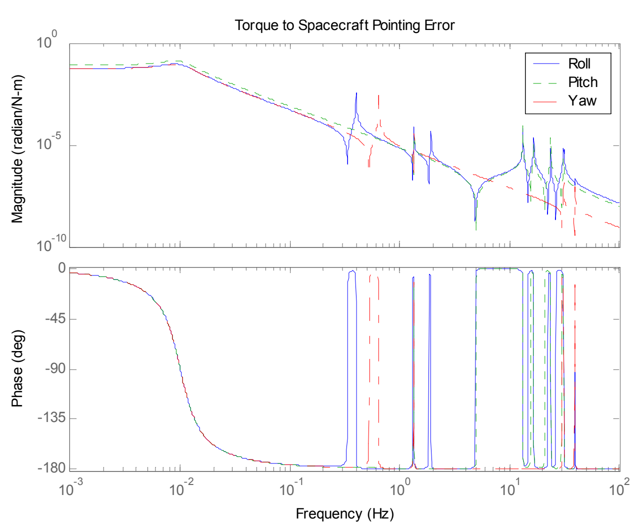
$$H_{\theta T}(s) = \sum_{i=1}^{n} \frac{1/J_i}{s^2 + 2\zeta_i \omega_i s + \omega_i^2} \qquad (4.4\text{-}1)$$

where

$$\omega_i = 2\pi f_i \qquad (4.4\text{-}2)$$

Equation 4.4-1 is plotted in Figure 4.4 for roll, pitch and yaw. Parameter values are given in Tables 4.4-1 through 4.4-3. When filtering roll axis torques with equations 4.4-1 through 4.4-3, Table 4.4-1 applies. When filtering pitch, Table 4.4-2 applies. When filtering yaw, Table 4.4-3 applies.

Figure 4.4: Torque-to-Spacecraft Pointng Error Transfer Function



4.4.1 Pointing Error

Analysis - Prior to delivery of a spacecraft mathematical model, use the torque-to-spacecraft pointing transfer function given in equation 4.4-1. Filtering the sensor unit torque time history in newton-meter units with equation 4.4-3 gives spacecraft pointing error displacement in radians

$$\frac{\theta(s)}{T(s)} = H_{\theta T}(s) \qquad (4.4\text{-}3)$$

4.4.2 Angular Rate Error

Analysis - Prior to delivery of a spacecraft mathematical model, use the torque-to-spacecraft pointing transfer function given in equation 4.4-1. Filtering with equation 4.4-4 gives spacecraft pointing error rate in radians per second

$$\frac{\dot{\theta}(s)}{T(s)} = sH_{\theta T}(s) \qquad (4.4\text{-}4)$$

Use at least a fourth-order Butterworth low-pass filter with a -3 dB response at 15 Hz to compute the angular rate response magnitude.

4.4.3 Acceleration Error

Analysis - Prior to delivery of a spacecraft mathematical model, use the torque-to-spacecraft pointing transfer function given in equation 4.4-1. Filtering with equation 4.4-5 gives spacecraft linear acceleration at a mount in meters per second units

$$\frac{\ddot{x}(s)}{T(s)} = as^2 H_{\theta T}(s) \qquad (4.4\text{-}5)$$

Use at least an eighth-order Butterworth band-pass filter with a -3 dB response at f_1 and f_2 to compute the acceleration response magnitude.

Table 4.4-1: Roll Torque and X-Axis Rotation Parameters

a (m)	*N*	*I*	f_i (Hz)	ζ_I (%)	J_i (kg-m^2)
1.5	12	1	0.01	30.0	4721
		2	0.40	2.0	10733
		3	1.34	0.1	59081
		4	1.92	0.1	34514
		5	13.24	0.1	972
		6	16.54	0.1	732
		7	23.56	0.1	3468
		8	30.55	0.1	5017
		9	30.91	0.1	2975
		10	31.00	0.1	1313
		11	31.17	0.1	1204
		12	39.36	0.1	25821

Table 4.4-2: Pitch Torque and Y-Axis Rotation Parameters

A (m)	*n*	*I*	f_i (Hz)	ζ_I (%)	J_i (kg-m^2)
1.5	9	1	0.01	30.0	3203
		2	1.35	0.1	89061
		3	13.24	0.1	820
		4	16.54	0.1	1620
		5	23.56	0.1	985
		6	30.55	0.1	55722
		7	30.91	0.1	8377
		8	31.00	0.1	3897
		9	31.17	0.1	6104

Table 4.4-3: Yaw Torque and Z-Axis Rotation Parameters

a (m)	N	i	f_i (Hz)	ζ_I (%)	J_i (kg-m^2)
1.5	5	1	0.01	30.0	4873
		2	0.64	2.0	10001
		3	1.35	0.1	76471
		4	31.00	0.1	45578
		5	39.36	0.1	73013

4.5 Predicted Instrument Force and Torque

4.5.1 PIFT Contents

Test - Quantitative checks of the predicted forces and torques against values measured in the laboratory will verify that they are being computed and that the coordinate frame is that of the instrument.

4.5.2 PIFT Timing

Analysis - The quantitative checks above will also show whether the time increments are as claimed.
Inspection - Satisfaction of lead-time requirement can be tested by inspection.

4.5.3 PIFT Resolution

Inspection - That the least significant bit provides the required resolution can be verified by inspection.

4.5.4 PIFT Accuracy

Test - Forces and torques will be measured in the lab with the instrument operating. These must match the predictions within the stated accuracy.

4.5.5 PIFT Format

Test - Successful unpacking of the predicted force and torque data will demonstrate satisfaction of these requirements.

5 Constraints

In order to ensure proper instrument performance or to prevent possible instrument damage, the following Government-approved constraints are imposed by the instrument developer on spacecraft integration and test activities, including launch, activation and operations.
No constraints have been identified at this time.

6 Deviations/Waivers

This section identifies GOES-R Instrument Requirements Document (GIRD) requirements that the government has relaxed or waived for this instrument. Where appropriate, corresponding GIRD paragraph titles and numbers are identified in parentheses.

There are no deviations or waivers at this time.

7 Acronyms

APID	application process identification
C&DH	command and data handling
CCR	configuration change request
GIRD	GOES-R Instrument Requirements Document
GOES	Geostationary Operational Environmental Satellite
GSFC	Goddard Space Flight Center
HES	Hyperspectral Environmental Suite
Hz	Hertz
ICD	Interface Control Document
IR	infrared
kg	kilogram
m	meter
Mbps	million bits per second
mg	milli-g's (g is gravitational acceleration at Earth surface)
NASA	National Aeronautics and Space Administration
PORD	Performance and Operation Requirements Document
TBD	to be determined by the contractor
TBR	to be reviewed by the contractor or the government
TBS	to be supplied by the government
UIID	Unique Instrument Interface Document

8 Allocation Rationale Matrix

UIID Spec. Req.	Title	Rationale
3.1.1	Instrument-to-Spacecraft Data Volume	HES RFI Attachments 13 January 2003
3.1.3	Telemetry Data Rate	TBS
3.2.1	Average Power	HES RFI Attachments 13 January 2003
3.2.2	Peak Power	TBS
3.2.3	Survival Heater Power	TBS
3.3.1	Mass Properties	HES RFI Attachments 13 January 2003
3.3.2	Volume	ibid.
3.3.3	Optical Port Field-of-View	
3.3.4	Radiator Field-of-View	
3.3.5	Mounting	
3.4.1	Pointing Error	Memos from D. Early to J. Criscione: • Instrument Disturbance Limits 18 December 2002 • ABI IRD Instrument Disturbance 28 May 2003
3.4.2	Angular Rate Error	ibid.
3.4.3	Acceleration Error	ibid.